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EQUIPMENT: MW-1/1A

SUBJECT: Troubleshooting Tips and General Service Information

This bulletin contains practical troubleshooting procedures which you will find useful for locating the cause of trouble in your MW-1/1A, and for checking its operation even when no trouble is suspected.

In troubleshooting, be aware that some of these tests pertain to the same type problem, so you may need to utilize more than one test for a given problem.

While this is not intended to be a complete troubleshooting guide, we feel it covers the most frequent problems you might have.

We suggest you keep this in your technical manual for a handy reference.

TESTING FOR MODULATOR PROBLEMS

This is a very important test to use on the transmitter because it can help you recognize problems that are often not apparent by other means. In some cases, it can also identify component or connection problems at a low power setting, thus avoiding the component stress that can occur at higher power levels.

This procedure gives a relative indication of the load that each pair of PA modules is placing on the Audio Driver. Problems found cause distortion, lack of positive peak capability, and sometimes faint fault indications.

1) To begin this test at a low stress level, turn the High power control all the way down.

2) Connect the positive lead of a VOM to the top of R11 on the Gating and Power Control board, A15.

3) Connect the negative lead to the bottom side of F2 on A15.

4) Turn the transmitter ON. Normally the voltage should be no higher than 0.3 VDC, even with the transmitter operating around 1 kw, unmodulated.

5) Move the voltmeter connection to the other fuses, F3-F7, one at a time, until you have checked the voltage at each of them.

6) If you identify any high readings, you should investigate the cause as outlined below. If the readings look okay, then progressively adjust the power level upward to the normal High power level. Check the voltage readings at intervals along the way to ensure that safe operating conditions are being maintained.

7) If the readings check okay at High power, apply tone modulation. This causes some increase in the readings, but they should still be below 0.5 volts.

Note

Each of the F2-F7 fuses feeds a pair of PA modules, so it will be important to determine whether a fault is related to a particular module, or a particular socket position. This can be done by swapping the position of a module in question.

For example, suppose you have a high reading on the far left fuse, F2. This fuse feeds modules A1 and A2. Remove module A1, and swap it with a module where you get a good reading. If the high reading moves with the module, then the problem is in the module. If the high reading stays with F2, then the fault is with the other module, A2 or their positions.

A high reading may be an indication of:

a) An open fuse on the Gating board (A15 F2-F7).

b) An open fuse in the +70 volt line (A25).

c) An open fuse in the +140 volt line (A26).

d) Shorted modulator transistors, QI-Q5 on one or both of the PA modules associated with the fuse with the high reading.

e) A damaged socket for one or both of the PA modules associated with the fuse having the high reading.

The following table, in order of left to right will help you identify which modules are associated with which Gating fuse.

F7	A1	&	A2
F6	A3	&	A4
F5	A5	&	A6
F4	A7	&	A8

F3	A9	&	A10
F2	A11	&	A12

TESTING IN THE RF DRIVER POSITION

If you are in a situation where you appear to have extensive PA module faults, it may be advantageous to use the RF Driver position as a test slot. By operating each module one at a time in the RF Driver position, you greatly simplify the troubleshooting, and can determine the condition of each without jeopardizing the full set of modules.

This type of test is performed with F2-F7 removed from the Gating and Power Control Board. With these fuses out, there should be no PA current. This alone is a significant observation to make, because it highlights the most severe modulator problems.

If there is PA current with F2-F7 pulled, then a PA fault light is also likely to be ON. In this case, the module(s) showing a fault indication have shorted transistors in the Q1-Q5 positions.

To do a more complete test on each module, swap each PA module into the RF Driver position, A13. Do not leave more than 2 empty PA sockets during this test. It is best to have a full complement of modules in the PA positions so that the RF Driver sees a normal load.

Take note of the RF Driver current for each module as it is tested in the Driver position. If you have a scope, you can probe the module output to observe its wave shape. Comparisons can be made between the various modules, but each should have a square wave output, and draw about 1.5 amps depending on the settings of the RF Driver Tuning and Loading.

You can also scope the signal at C15 in the RF Driver tuning network with audio applied to the transmitter. The RF Driver should produce an envelope, which will be quite distorted in this test condition. The important observation in this test is that the module produces both positive and negative modulation.

AUDIO DRIVER (A17) OUTPUT VOLTAGE SWING

This test is often useful in finding the reason for a lack of positive peak capability and distortion. It checks the capability of the Audio Driver in an unloaded condition.

1) Remove the Gating fuses, A15 F1-F7.

2) Connect a scope to the Audio Driver output at P16 pin 12 or A15 pin 3.

3) Turn the transmitter ON, and apply audio to the transmitter. There should not be any power output.

4) The Audio Driver output voltage swing should be about 130 volts. It will probably be heavily clipped, but this is okay under these conditions. "PA VOLTS" should be 60 to 70 volts.

A low peak to peak voltage could be an indication of:

a) An abnormally low AF DVR HI voltage. Check multimeter.

b) A17, CR4 and/or CR5 shorted. Try disconnecting one of them to see if the situation changes.

c) A17, CR2 shorted.

d) A17, Q2 leaky.

AUDIO DRIVER Q4 OPERATION

This circuit provides the source of bias that is used to adjust the power level, and is used to limit how high the PA Voltage can be turned up.

Operation of this circuit can be checked at turn on with A15 F2-F7 removed. The "AF DVR CONTROL" reading should be about 24 volts initially, but will decrease to less than 15 volts as "PA VOLTS" reaches 60 to 70 volts.

Results other than this could be caused by:

a) Q4 shorted ("AF DVR CONTROL" will remain at 24 volts while "PA VOLTS" soars past 70 volts).

b) A17 CR3 shorted (no "AF DVR CONTROL," no "PA VOLTS").

c) A17 Q3 shorted ("PA VOLTS" pinned, "AF DVR CONTROL" zero)

RF DRIVER MODULATION

Use this test to help troubleshoot carrier shift, distortion, poor modulation capability, or an abnormal "RF DVR AMPS" reading.

1) Modulate the transmitter to 100% with a tone.

2) Connect a X10 scope probe to the junction of L18 and L19 above the IPA module.

3) Observe the modulation envelope at this point.

4) The envelope should be about 50-70% modulated. Normally it will be fairly distorted but not hard clipped.

The likely causes for no modulation at the RF DRIVER would be A15 F1 being open, and/or blown transistors in the Q1 - Q5 positions on the RF Driver.

Likely causes for clipping on the positive excursion would be:

a) A25 F13 open

b) A26 F13 open

c) Bad transistor(s) in the modulator section of the RF Driver module. Check transistors Q1-Q5.

The cause for clipping on only the negative excursion would be:

a) Q2 and/or Q5 shorted on the RF Driver module.

PA MODULE DUTY CYCLE

The following test should be used in determining the cause for a faint fault indication that is not found by checking the modulator performance. You will need an oscilloscope with 15 Mhz bandwidth or higher for this test.

1) Connect the oscilloscope to the output (brass block or terminal 16) of each PA module with a X10 probe.

2) Observe a square wave whose peak to peak amplitude should be about the same as the "PA VOLTS" reading, and whose duty cycle is 50 +/-5%. Some ringing on the square wave should also be observed.

An error in amplitude is a problem associated with the modulator section of the module. Measure the voltage at the fuse on the PA module in question. It should be equal to the "PA VOLTS" reading within 0.3 volts. Check or replace the modulator transistors, Q1-Q5.

An error in duty cycle is caused by:

a) A severe gain mismatch between Q6 and Q7. Try swapping Q6 for Q7. Sometimes this will either correct the problem, or confirm that the duty cycle problem is caused by a gain difference.

b) A fault with the transformer assembly TI.

c) Insufficient RF drive.

PA MODULE CURRENT BALANCING

The purpose of this test is to obtain equal stress among the PA modules for optimum reliability. This assumes that all PA modules are working correctly.

Using a DC ammeter that can measure several amps, you can check the amount of current each module is drawing.

1) Turn the transmitter off.

2) Open the back door, and remove one of the F1-F12 fuses from A25. Substitute the DC ammeter for the fuse, with the positive lead on the +70 volt bar.

CAUTION!

Be sure that the ammeter leads will not short to ground. The power supply is capable of extremely high short circuit current.

3) Be sure that there is no audio applied to the transmitter.

4) Turn the transmitter back on and allow a minute for the Regulator to adjust.

5) Adjust Tuning and Loading for 52 Volts/22.5 Amps.

6) Read the current on the meter. It should be 1/12 of the "PA AMPS" reading.

Note

"PA AMPS" should never exceed 24.

7) Using the same procedure, check the current draw of the other PA modules.

8) If necessary, make adjustments to L1-L12 to achieve uniform current draw.

Note

A severe imbalance in current may be a fault of the module. Before making a coil adjustment, try interchanging modules to see if the current imbalance follows the module.

Compressing a coil results in a decrease in PA current for the module associated with that coil. Expanding a coil causes an increase in current. Be sure to dip "PA volts" after making an adjustment.

Typically, L11 and L12 will have to be slightly compressed in relation to L1-L10 in order to achieve a balance.

REL/VSWR NULLING

VSWR overloads can be caused by improper transmitter loading adjustment or improper REL/VSWR circuit adjustment.

1) Assuming that there are no PA module problems, the PA Loading control should be adjusted such that PA AMPS reads 22.5 when PA volts reads 52 volts.

2) With the correct loading ratio established, the REL/VSWR circuit should be adjusted for a zero reading on the power meter in the REL/VSWR position. This is accomplished by adjusting the trimmer capacitors at the top of the Directional Coupler board, A21.

Note

If you are unable to null the reading, there are some possible causes to consider. If the transmitter still has the factory settings in the Output Network, it may be that a capacitor in the Output Network has changed value or that the transmitter is operating into a strange load impedance. However, if the transmitter has undergone a frequency change, it may it will be necessary to make a component change on the Directional Coupler board. The following guidelines will help you determine what to change, assuming there is no fault with the Output Network:

In either case, if the trimmer capacitor tightens down for the minimum reading, then more capacitance is needed in parallel it. C19 parallels C20, and C23 parallels C22.

Conversely, you will need to decrease the parallel values if the trimmer capacitors are fully loosened for the best reading.

If there is no capacitor in the C23 position, you can create the same effect by jumpering out some of the chokes in the L1A-L1F positions.

VSWR OVERLOAD OPERATION

1) To test the VSWR overload, rotate the PA Loading control in the direction which lowers PA AMPS. Make sure the transmitter is not being modulated. The REL/VSWR reading should increase as you rotate the PA Loading control. The VSWR trip circuit threshold should be 500-700 on the meter.

2) Return the loading control to its proper setting.

3) VSWR overloads can be caused by improper impedance external to the transmitter. Check to see if a problem exists when operating on the internal dummy load. The dummy load impedance is typically 52 ohms +j5.

4) Assuming the transmitter has worked previously on the antenna, a bad coax or a failed capacitor in the ATU or phasor is the most probable causes of the VSWR.

5) If the VSWR trips are caused by something internal to the transmitter and occur only with modulation, try disconnecting E1, the glass spark gap. E1 is located in the top of the transmitter, near C3, mounted in a grommet in a metal bracket. The failure mode of this type of spark gap is developing a low resistance. This can cause the spark gap to get hot.

6) Also check for loose connections in the output network, including the contact roller in L14, the loading coil.

7) If the VSWR overload is of a continuous nature (i.e., no power output because of it), remove A15 F2-F7. The transmitter should then have a PA VOLTS of approximately 60 and PA AMPS at zero. It should not produce RF power output as it does during the VSWR cycling. With no RF output, a real VSWR overload is not possible. A VSWR overload under these conditions would indicate a problem in the VSWR trip circuit (A18 Q3, Q4, or Q6).

8) If the overloads do not occur with the Gating fuses removed, the VSWR condition is apparently real, and of a fairly extreme nature such as an open or short in the antenna system. Be sure to test the transmitter on the dummy load.

9) If a normal (zero) REL/VSWR reading is indicated, yet VSWR overloads occur during modulation on the antenna, there are two possible causes. A voltage breakdown could be occurring with one of the capacitors in the ATU or phasor. If the overload occurs with all frequencies of modulation, this is likely to be the cause.

10) If the overload seems particularly sensitive to high frequency modulation, then narrow antenna bandwidth is indicated. Note the action of the REL/VSWR meter. An upward deflection with modulation is a symptom of bandwidth limitations. The greater the meter reading, the more limited the bandwidth. It also depends on the amount of high frequency audio.

11) If the transmitter indicates that the antenna bandwidth is sharply limited, an antenna impedance sweep should be made, and an antenna broadbanding scheme should be considered.

12) Tower static is characterized by a gradual buildup on the REL/VSWR meter, usually during poor weather conditions. This static buildup continues until the tower base ball gaps arc over. The REL/VSWR reading then falls to zero indicating the charge has cleared. A static drain choke at the tower base to ground should prevent tower static buildup.

13) Guy wire static is similar to a nearby lightning strike in that no charge is registered on the REL/VSWR meter. Instead, the static charge builds up on the guy wires and ultimately arcs across the insulators to the tower. The charge is then removed by the static drain choke and/or the ball gaps at the base of the

tower. The guy wire static buildup may be prevented with static drains across the top set of guy wire insulators, or by using non-metallic guy wires.

DC OVERLOADS

DC overloads fall into two categories:

Those which occur at transmitter turn on, immediately shutting the transmitter off, and the random type.

To troubleshoot the immediate type overload:

1) Remove A15 F2-F7. Turn the transmitter on. The PA modules should not draw any current, regardless of the Audio Driver output. Observe the PA VOLTS meter. If it pins, the problem is on the Audio Driver (Q3 is probably shorted. Other possibilities are a shorted Q1, F2 blown, or CR1 shorted.

2) If the transmitter still DC overloads at turn on with A15 F2-F7 removed, observe whether K2 pulls in momentarily. If K2 does not, the power supply is not being energized, therefore, a real DC overload is not possible. Look for a fault in the protection circuitry such as A22 Q3 shorted (A22 K4 would always be closed) A18 Q1 (which can be removed for test purposes).

DC overloads which occur randomly, during normal programming:

1) Check the DC overload setting. The normal DC overload setting is made at 1100 watts output with 100% sine wave modulation at 20 hz.

2) If correct adjustment is not achievable, A22 C3 may be open. Its purpose is to slow the overload circuit down, and it may be drying out due to age. You might find that the transmitter will not overload when modulated with a higher frequency such as 1 Khz.

It is not normal to experience DC overloads during ordinary programming. If the sensitivity is set correctly and overloads persist, then it is evident that the audio going into the transmitter contains sub audible signals whose amplitude is sufficient to trip the DC overload.

140 Volt Supply Adjustment

1) Check the 140 V supply reading. Its normal factory setting is 135 V, without modulation.

2) Observe the position of the wiper contact of T2 after operating at High power. You can make it stop in its operating position by shutting the transmitter OFF via the front panel circuit breaker, thus not allowing the variac to return to its fully CCW position. Preferably, its wiper contact will be in the middle portion of its range.

3) If the wiper contact is positioned at or near either extreme, change the tap on T1. If the wiper contact on T2 is counterclockwise as viewed from the top, move the tap on T1 to a higher voltage setting.

4) Check to see if the A22 regulator circuitry is working by turning the front panel Regulator adjust control. Typically, the range of voltage adjustment is 10 volts.

5) On A22, K1 closes to lower the 140 volt supply voltage. K2 closes to raise the supply voltage. During operation, these relays will operate every several seconds.

6) Typical failure modes of the A22 regulator circuit are:

   a) Always raising - Q2 shorted
   b) Always lowering - CR5, Q1, or CR1/CR2 shorted.

CAUTION

A22 pins 6 and 15 are not fused from the 140 V supply. Be very cautious if attaching meter leads to these terminals.

T2 Variac Failures. Loss of contact in the variac assembly will cause the 70/140 volt supply to intermittently dropout. This shows up on the multimeter on the 70 and 140 volt supply readings, and is otherwise characterized by the PA Volts, PA Amps, and Power Output readings all dropping intermittently without any overload indication.

To temporarily get around the problem, you can remove relays K1 and K2 from the A22 Relay and Regulator board. This will remove the voltage that powers the motor for the variac.

With the AC power off, you can manually position the rotating plate of the variac to a position where it maintains good contact.

POWER SUPPLY REGULATOR (T2) OPERATION

The purpose of the T2 Regulator is to maintain the 70/140 volt supplies at an optimum value so that good peak modulation is maintained, without incurring unnecessary stress to the modulator section of the modules.

Note

The importance of the regulator depends on the particular AC line voltage stability, and whether full positive peak modulation is needed for your station. If the AC line voltage is reasonably stable, you might choose to leave the T2 variac in a fixed position, with the supply voltage never exceeding 140 volts. If you decide on a fixed setting, be sure to take into account Low power operation at the highest reasonable AC line voltage that you will get.

To disable automatic adjustment of the T2 variac, remove K1 and K2 from the A22 Relay and Regulator board. With the AC power off, you can manually set T2 by turning the rotating contact plate.

Feedback Failure. The main symptom of an overall negative feedback failure is the power output tending to drift high. On High power, the power output will probably drift high enough to incur a DC overload. Distortion also increases without the overall negative feedback.

If you see these symptoms, replace CR3 and CR4 on the Directional Coupler board, A21. Use 1N3070 diodes (Harris part number 384-0612-000) in place of 1N914 diodes. These are more rugged.

If you have a need to measure the overall negative feedback, you can find it at R26 on the Audio Input board, A18. Connect the voltmeter to the side of R26 that is closest to the connector, P18.

With 1 KW output, the negative feedback voltage should be -12 to -15 volts.

To increase the amount of feedback, you would have to decrease the value of C17/C18 on the Directional Coupler board.

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Transistor Types & Chronology
The transistor type originally used in the PA modules in the RF positions (Q6 & Q7) was the 2N6340. The SJ7349 followed, which was later replaced by the SJ3125. All of them were sold under the Harris part number 380-0513-000. There is no problem having a pair of one type in one module, and another type in another module. The RF transistors are critical enough in their parameters that would be hard to find suitable substitutes.

Q3-Q5 on the PA Modules were originally the 2N6254 type, but were later replaced with the MJ15015. Both were sold under Harris part number 380-0670-000. Although these transistors are just for DC and audio, they are somewhat special in terms of their current handling and high safe operating area.

TIP47. A number of customers have successfully used the NTE198 as a replacement for the TIP47, which is still available. The specifications are the same in nearly all aspects, but some users believe that it is more rugged.

PA Socket Replacement. The sockets that the PA modules plug into may need to be replaced, particularly as the transmitter gets older. Corrosion can eat away on the underside of the sockets, and cause the terminals to break away from the connector body.

1) If you have determined that you need to replace a socket, remove the module and the bolts which fasten the socket to the deck.

2) The wires attached to the socket may have become stiff with age, so you will need to be gentle with the wire harness in order to avoid wire breakage at other sockets.

3) Take note of what wires are connected to each pin.

4) Carefully lift the socket upward, and use wire cutters to clip the terminals from the sockets. You will need to preserve as much wire length as possible.

5) Temporarily fasten a new socket in place upside down. Mounting the socket this way will hold the socket steady, and will make it easier to solder the wires.

6) Remove the screws, and carefully orient the socket to its proper position.

7) Install the bolts, but leave them just loose enough for the socket to adjust to the position of the module.

8) Check the voltage drops on the Gating and Power Control board as described in "Testing for Modulator Problems".

PA Tuning assembly. If the PA Tuning knob is difficult to turn, it may be that the mechanical drive is out of alignment. It will be necessary to remove it from the transmitter in order to service it. The entire PA tuning assembly, from where it bolts to the sides of the PA module framework to the shelf where the output network resides, can be removed from the transmitter.

1) Unplug all twelve banana plugs from the outputs of the PA modules.

2) Disconnect the brown HV wire which goes up to L13 from the end of the bar where the PA Tuning coils are connected.

3) Loosen the set screws in the coupling, and disengage the PA Tuning shaft.

4) Remove the four bolts from the sides of the PA Module framework.

5) Remove the four bolts which fasten the PA Tuning assembly to some standoffs on the underside of the output network shelf. At this point, the PA Tuning assembly will drop, and you can then remove it from the transmitter.

6) With the PA Tuning assembly out on a table, it will now be possible to set the drive screws at each end of the assembly so that the slug rack is straight. To do so, you will first need to loosen the appropriate set screws so that the drive screws can turn independently.

7) Lubricate the moving parts. A lightweight oil such as WD-40 is good for cleaning, but will quickly evaporate. For long term lubrication, use lithium grease.

8) Install the assembly back in the transmitter.

If you have any questions or comments please contact:

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